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ELECTROLESS PLATING APPARATUS AND ELECTROLESS PLATING METHOD

Field of the Invention

The present invention relates to an electroless plating apparatus and an electroless plating method.

Background of the Invention

In a fabrication of a semiconductor device, there is performed a formation of a wiring on a semiconductor substrate.

Along with a recent trend of high integration of semiconductor devices, miniaturization of the wiring has been progressed and fabrication technique thereof has been accordingly developed. For example, as a method for forming a copper wiring, there has been utilized a dual damascene method wherein a copper seed layer is formed by a sputtering and a groove is buried by an electroplating to form a wiring and an interlayer connection. In this method, it is difficult to perform the electroplating on a surface to be coated where the seed layer is not formed.

Meanwhile, as a plating method wherein the seed layer is not required, there is an electroless plating method. In the electroless plating method for forming a coating by a

chemical reduction, the formed coating acts as a self-catalyst, so that the coating made of a wiring material can be formed continuously. In accordance with the electroless plating, it is unnecessary to form the seed layer in advance (or it is unnecessary to form the seed layer all over the surface), and there is a reduced concern for non-uniformity in a film thickness when forming the seed layer (particularly, step coverage in a recess and protrusion).

Further, there have been disclosed technologies of an electroless plating, as described below (see references 1 and 2).

Reference 1: Japanese Patent Laid-open Application No. 2001-73157 (Fig. 1 on page 4)

Reference 2: Japanese Patent Laid-open Application No. 2001-342573 (Figs. 2 and 3 on pages 4 and 5)

Summary of the Invention

In the electroless plating, the plating solution is made of many chemicals, so that a composition thereof is likely to be changed. Therefore, the plating solution becomes unstable and the life span thereof gets shortened. Further, the deposition rate of the coating in the electroless plating is generally lower than that in the electroplating, and the film forming rate and the

characteristic of the coating to be formed are likely to be changed depending on process conditions such as temperature, composition ratio, flow velocity of the plating solution and the like. In the aforementioned references 1 and 2, since the electroless plating is performed while the plating solution is collected on the substrate, the characteristic of the plating solution is likely to be changed during the film formation. For the same reason, it is difficult to secure uniformity in a processing of a substrate while performing the electroless plating on the substrate. Further, since the amount of plating solution to be used per unit amount of deposition gets larger due to the instability of the plating solution as mentioned above, cost tends to increase.

It is, therefore, an object of the present invention to provide an electroless plating apparatus and an electroless plating method capable of securing uniformity in a processing of a substrate even in case of using a small amount of processing solution.

For achieving the object, in accordance with one aspect of the present invention, there is provided an electroless plating apparatus, including: a substrate supporting unit for supporting a substrate; a plate disposed to face the substrate supported by the substrate supporting unit; a processing solution discharge unit, formed on a surface of the plate which faces the substrate, for

discharging a processing solution; and a gap adjusting unit for changing a gap between the plate and the substrate.

By discharging the processing solution from the processing solution discharge unit while the plate being disposed close to the substrate supported by the substrate supporting unit by the gap adjusting unit, it is possible to perform an electroless plating on the substrate.

Since the processing solution flows through a gap formed between the substrate and the plate, the flow of the processing solution is generated on the substrate, and thus it is possible to reduce non-uniformity of concentration at an interface, in which a coating is deposited. As a result, it is possible to form a coating on the substrate very uniformly. Further, since the gap formed between the substrate and the plate is adjusted by the gap adjusting unit, a volume of the plating solution on the substrate can be controlled. Therefore, it is possible to reduce the amount of the processing solution used by making small the gap.

The term "processing solution" used herein contains at least liquid chemical for an electroless plating solution, and may contain a cleaning fluid and the like for use in pre-treatment and post-treatment of the electroless plating, if necessary. Namely, the term "the electroless plating apparatus" includes any of apparatus, which performs an electroless plating by using an electroless plating solution

as a "processing solution", and additionally performs the pre-treatment or post-treatment of the electroless plating.

Here, the electroless plating apparatus may further include a heating unit for heating the plate.

Since the plate is heated, the uniformity in a temperature of the processing solution at the gap between the substrate and the plate can be readily secured. As a result, it is possible to further improve the uniformity in the coating formed on the substrate, to thereby significantly increase the deposition rate of the coating.

The electroless plating apparatus may further include an inclination adjusting unit for changing inclinations of the substrate and the plate as a unit.

Since the substrate is tilted, a gas staying in a space between the substrate and the plate is immediately removed. Therefore, it is possible to reduce the non-uniformity in the coating, resulting from bubbles remaining on the substrate. Further, it is possible to rapidly remove a gas (e.g., hydrogen) generated during the formation of the coating from the space between the substrate and the plate. In this way, it is possible to reduce the non-uniformity in the coating, due to the bubbles of the processing solution.

The electroless plating apparatus may further include a solution supply unit for supplying a processing solution to the plate after adjusting the temperature thereof.

By heating the processing solution in advance, it is

possible to further improve the uniformity in a temperature thereof.

Here, the solution supply unit may supply the processing solution in turn. By supplying plural processing solutions in turn, it is possible to perform various processes of the substrate. For example, by supplying liquid chemicals for an electroless plating, it is possible to form plural coatings on the substrate. Further, by using as a processing solution a liquid for use in the pre-treatment or the post-treatment of the electroless plating, it is possible to continuously perform the electroless plating processing, the pre-treatment and the post-treatment thereof. As for specific examples of the pre-treatment and the post-treatment, there may be enumerated a cleaning processing of the substrate, an activating processing thereof and the like.

The solution supply mechanism may have a processing solution producing unit for producing a processing solution by mixing plural chemicals. The amount of processing solution to be required is produced right before it being supplied by the processing solution producing unit, so that the processing solution can be stably supplied. As a result, the uniformity in the coating formed on the substrate can be further improved.

The electroless plating apparatus may further include: a second plate disposed to face a second surface of the substrate different from a surface thereof facing the plate;

a liquid discharge unit, formed on a surface of the second plate facing the second surface of the substrate, for discharging a liquid at a controlled temperature; and a second gap adjusting unit for changing a gap between the second plate and the substrate.

By disposing the second plate close to the substrate by the second gap adjusting unit and supplying heated liquid from the liquid discharge unit, the substrate can be heated from a rear surface thereof. As a result, both of front and rear surfaces of the substrate can be heated, and thus the uniformity in a temperature of the substrate can be further improved.

The term "liquid" used herein does not necessarily contain a liquid chemical for an electroless plating, in contrast with the term "processing solution". The reason is that the "liquid" is sufficient to serve as a heat medium heating the second plate. As for the "liquid", pure water may be used, for example. In case of using pure water, it can be prevented that the processing solution spreads into the rear surface of the substrate from the front surface thereof. Thus, it is possible to prevent the rear surface of the substrate from being contaminated by the processing solution (further, components thereof, e.g., metal ions forming the plating solution).

Here, the heating of the "liquid" may be carried out by a heating means such as a heater or the like, which is

provided at the second plate, but it may be performed by a solution supply unit for supplying a liquid discharged from the liquid discharge unit into the second plate after adjusting the temperature thereof. By adjusting the temperature of the liquid in advance, the uniformity in a temperature of the substrate can be further improved.

The electroless plating apparatus may further include an operational nozzle for discharging a processing solution onto the substrate.

By using the nozzle, the processing solution can be supplied into a desired portion of the substrate, and thus flexibility in the supply of the processing solution onto the substrate may be improved.

In accordance with another aspect of the present invention, there is provided an electroless plating method, including: a supporting step for supporting a substrate; a disposing step for disposing a plate to face the substrate supported at the supporting step; and a coating forming step for forming a coating on the substrate by supplying a processing solution between the plate and the substrate disposed to face the plate at the disposing step.

By disposing the supported substrate closed to the plate and supplying the processing solution into therebetween, an electroless plating may be performed on the substrate.

Since the processing solution flows through a gap

formed between the substrate and the plate, the flow of the processing solution is generated on the substrate, and thus fresh processing solution can be supplied on the substrate.

Here, the disposing step may include a gap adjusting step for adjusting a gap between the substrate and the plate, such that the gap gets smaller than a thickness of the processing solution when the processing solution is kept on the substrate by a surface tension.

By adjusting the gap between the substrate and the plate, it is possible to reduce the amount of the processing solution used.

Further, the coating forming step may include a processing solution generation step for producing a processing solution by mixing plural chemicals.

By generating the processing solution by the amount to be required right before it being supplied, the processing solution can be supplied stably. As a result, the uniformity in the coating formed on the substrate can be further improved.

Prior to the coating forming step, an inclining step for inclining the substrate supported at the supporting step may be further included.

Since the substrate is tilted, a gas staying in a space between the substrate and the plate can be substituted rapidly by the processing solution. Further, it is possible to rapidly remove a gas (e.g., hydrogen) generated during

the formation of the coating from the space between the substrate and the plate. In this way, it is possible to reduce the non-uniformity in the coating, due to the bubbles of the processing solution.

Prior to the coating forming step, a heating step for heating the substrate supported at the supporting step may be further included.

Since the plate is heated, stability and uniformity in a temperature of the processing solution at a gap can be readily secured. As a result, the uniformity in the coating formed on the substrate can be further improved, and thus the deposition rate thereof can be further increased.

Brief Description of the Drawings

Fig. 1 provides a partial cross sectional view for showing an electroless plating apparatus in accordance with a first embodiment.

Figs. 2A and 2B are of a plane view for showing an exemplary lower surface of an upper plate in the electroless plating apparatus described in Fig. 1.

Fig. 3 sets forth to a partial cross sectional view showing a state where a wafer W and the like installed in the electroless plating apparatus of Fig. 1 are tilted.

Fig. 4 offers a flowchart for showing an exemplary sequence in case of performing an electroless plating by

using the electroless plating apparatus in accordance with the first embodiment.

Fig. 5 is a partial cross sectional view for showing a status of the electroless plating apparatus in case of performing the electroless plating by following the sequence described in Fig. 4.

Fig. 6 is a partial cross sectional view for showing a status of the electroless plating apparatus in case of performing the electroless plating by following the sequence described in Fig. 4.

Fig. 7 is a partial cross sectional view for showing a status of the electroless plating apparatus in case of performing the electroless plating by following the sequence described in Fig. 4.

Fig. 8 is a partial cross sectional view for showing a status of the electroless plating apparatus in case of performing the electroless plating by following the sequence described in Fig. 4.

Fig. 9 is a partial cross sectional view for showing a status of the electroless plating apparatus in case of performing the electroless plating by following the sequence described in Fig. 4.

Fig. 10 is a partial cross sectional view for showing a status of the electroless plating apparatus in case of performing the electroless plating by following the sequence described in Fig. 4.

Fig. 11 is a partial cross sectional view for showing a status of the electroless plating apparatus in case of performing the electroless plating by following the sequence described in Fig. 4.

Detailed Description of the Preferred Embodiments

(First embodiment)

Hereinafter, an electroless plating apparatus in accordance with the first embodiment of the present invention will be described in detail with reference to the accompanying drawings.

Fig. 1 is a partial cross sectional view for showing a configuration of an electroless plating apparatus 10 in accordance with the first embodiment of the present invention.

In the electroless plating apparatus 10, an electroless plating processing, a pre-treatment thereof, a cleaning processing after plating and a dry processing can be performed on the wafer W of a substrate by using a processing solution.

As for the processing solution, various liquids such as liquid chemicals for the pre-treatment and the after-treatment of the plating, pure water and the like, as well as the liquid chemical for the electroless plating can be

employed.

As for the liquid chemical for use in the electroless plating, the following materials may be used by being mixed with each other and resolved in the pure water.

1) Metal salt: It is a material for providing metal ions for forming a coating. In case of a copper coating, metal salt is, e.g., copper sulfate, copper nitrate, or copper chloride.

2) Complexing agent: It is a material to convert a metal into a complex such that metal ions are not precipitated as hydrides under strong alkaline condition to thereby improve stability of the metal in a solution. As for the complexing agent, there may be used, e.g., HEDTA, EDTA, and ED as an amine based material; and citric acid, tartaric acid and gluconic acid as an organic material.

3) Reducing agent: It is a material for catalytically reducing and precipitating metal ions. As for the reducing agent, there may be used, e.g., hypochlorous acid, glyoxylic acid, stannic chloride, or boron hydride compound or cobalt(II) nitrate.

4) Stabilizer: It is a material for preventing a plating solution from being naturally decomposed due to non-

uniformity of oxide (cupric oxide in case of a copper coating). As for the stabilizer, there may used as nitrogen based material, e.g., bipyridyl, cyanide compound, thiourea, O-Phenanthroline, or neocuproine. Herein, bipyridyl preferentially forms a complex with, e.g., monovalent copper.

5) pH buffer: It is a material for suppressing variation in pH while the reaction of the plating solution progresses. As for the pH buffer, there may be used, e.g., boric acid, carbonic acid or oxycarboxylic acid.

6) Additive: There is a material for facilitating or suppressing the deposition of the coating, or for modifying the surface or the coating.

. As a material for suppressing the deposition rate of the coating to stabilize the plating solution and to improve the characteristic of the coating, there may be used, e.g., thiosulfuric acid or 2-MBT as a sulfuric material.

. As a material for lowering surface tension of the plating solution to make the plating solution be placed uniformly on the surface of the wafer W, there may be used, e.g., polyalkylene glycol or polyethylene glycol as a nonionic material of the surfactant.

As shown in Fig. 1, the electroless plating apparatus 10 includes a base 11, a hollow motor 12, a wafer chuck 20

of a substrate supporting unit, an upper plate 30, a lower plate 40, a cup 50, nozzle arms 61 and 62, a substrate inclining mechanism 70 of an inclination adjusting unit and a solution supply unit 80. Here, the hollow motor 12, the wafer chuck 20, the upper plate 30, the lower plate 40, the cup 50 and the nozzle arms 61 and 62 are directly or indirectly connected to the base 11; moved with the base 11; and tilted by the substrate inclining mechanism 70.

The wafer W is maintained and fixed by the wafer chuck 20, which is formed of wafer supporting claws 21, a wafer chuck bottom plate 23 and a wafer chuck supporting unit 24.

The plural wafer supporting claws 21 are disposed on an outer periphery of the wafer chuck bottom plate 23 to maintain and fix the wafer W.

The wafer chuck bottom plate 23 connected to the upper surface of the wafer chuck supporting unit 24 is of a substantially circular flat plate, and disposed on the bottom surface of the cup 50.

The wafer chuck supporting unit 24 of a substantially cylindrical shape is connected to a circular opening prepared at the wafer chuck bottom plate 23, and configured as a rotation axis of the hollow motor 12. As a result, it is possible to rotate the wafer chuck 20 by operating the hollow motor 12 while maintaining the wafer W.

Figs. 2A and 2B are of a plane view showing an exemplary lower surface of the upper plate 30, respectively.

As described in Figs. 1, 2A and 2B, the upper plate 30 disposed to face the top surface of the wafer W is of a substantially circular flat plate type, and functions to supply onto the wafer W a processing solution, such as liquid chemical, pure water or the like, and to heat the processing solution. For the reason, it is preferable that the size of the upper plate 30 is similar to or greater than that of the wafer W, in order to efficiently manufacture the semiconductor device using the wafer W. Specifically, it is preferable that the size of the upper plate 30 is greater than 80 % or 90 % of an area of the wafer W.

Here, the upper plate 30 is made somewhat smaller than the wafer W in Fig. 1 such that the upper plate 30 is not contacted with the wafer supporting claws 21. However, it is not an absolute condition, and the upper portion of the wafer supporting claws 21 may be configured not to be protruded from the top surface of the wafer W, in order to avoid such a condition.

The upper plate 30 has a heater H, processing solution injection openings 31, a processing solution introduction unit 32 and a temperature measuring mechanism 33, and is connected to an elevating mechanism 34.

The heater H is a heating unit, such as a heat transfer line or the like, for heating the upper plate 30. The caloric power of the heater H is controlled by a controller (not shown), based on a temperature measurement

result of the temperature measuring mechanism 33, such that the upper plate 30, and further, the wafer W are maintained at desired temperatures (e.g., in the range from room temperature to about 60 ℃).

One or more processing solution injection openings 31 are formed at a lower surface of the upper plate 30, through which the processing solution introduced from the processing solution introduction unit 32 is to be discharged.

As shown in Figs. 2A and 2B, the heater H and the processing solution injection openings 31 are dispersedly disposed at the lower surface, respectively, so that uniformities in a temperature of the upper plate 30 and a supply of the processing solution can be realized. The processing solution injection openings 31 are radially disposed from the center of the lower surface of the upper plate 30, i.e., it is radially disposed, e.g., in four directions (Fig. 2A) or three directions (Fig. 2B). However, such arrangements are illustrated as an example, and the processing solution injection openings 31 may be disposed, e.g., in longitudinal and transversal directions, other than radially. Namely, the numbers, shapes and arrangements of the heater H and the processing solution injection openings 31, may be properly selected as long as uniformity in distributions of a temperature of the upper plate 30 and a supply of the processing solution can be obtained consequently.

The processing solution introduction unit 32 is placed at an upper side of the upper plate 30; and the processing solution introduced thereinto is discharged through the processing solution injection openings 31. As for the processing solution to be introduced into the processing solution introduction unit 32, there may be used pure water (RT: room temperature), or heated liquid chemicals 1 and 2 (e.g., in the range from room temperature to about 60 ℃). Further, liquid chemicals 1 and 2 to be mixed in a mixing box 85 explained hereinafter (multiple liquid chemicals containing other liquid chemicals may be mixed, if necessary) may flow into the processing solution introduction unit 32.

The temperature measuring mechanism 33 is a temperature measurement unit such as a thermocouple or the like, buried into the upper plate 30, for measuring a temperature of the upper plate 30.

The elevating mechanism 34, connected to the upper plate 30, vertically moves the upper plate 30 while allowing it to face the wafer W, so that the gap between the upper plate 30 and the wafer W can be controlled at, e.g., about 0.1 ~ 500 mm. During the electroless plating, the wafer W is disposed close to the upper plate 30 to limit the size of the gap (e.g., 2 mm or less of the gap between the wafer W and the upper plate 30), so that the processing solution is uniformly supplied onto the surface of the wafer W and the

amount of consumption thereof is reduced.

As described in Fig. 1, the lower plate 40 disposed to face the bottom surface of the wafer W is of a substantially circular flat plate type; and supplies heated pure water to the bottom surface of the wafer W to properly heat the wafer W while it being disposed close to the wafer W.

For efficiently heating the wafer W, it is preferable that the size of the lower plate 40 is approximately similar to that of the wafer W. Specifically, it is preferable that the size of the lower plate 40 is greater than 80 % or 90 % of an area of the wafer W.

The lower plate 40, having a processing solution injection opening 41 on the center of the upper surface thereof, is supported by a supporting unit 42.

The processing solution passing through the supporting unit 42 is discharged through the processing solution injection opening 41. As for the processing solution, there may be used pure water (RT: room temperature) or heated pure water (e.g., in the range from the room temperature to about 60 ℃).

The supporting unit 42 penetrating through the hollow motor 12 is connected to an elevating mechanism (not shown) of a gap adjusting unit. By the operation of the elevating mechanism, the supporting unit 42, and further, the lower plate 40 can be vertically moved.

The cup 50, which accommodates therein the wafer chuck

20 and discharges therefrom the processing solution used for the processing of the wafer W, has a cup side portion 51, a cup bottom plate 52 and a waste liquid line 53.

The cup side portion 51 is of a substantially cylindrical shape, wherein the inner periphery thereof is formed along the outer periphery of the wafer chuck 20 and the top portion thereof is disposed in the vicinity of the upper portion of the supporting surface of the wafer chuck 20.

The cup bottom plate 52 connected to the lower portion of the cup side portion 51 has an opening at a position corresponding to the hollow motor 12; and the wafer chuck 20 is disposed at a position corresponding to the opening.

The waste liquid line 53 connected to the cup bottom plate 52 is to discharge from the cup 50 the waste liquid (the processing solution used for the processing of the wafer W) into the waste line or the like of the factory, in which the electroless plating apparatus 10 is installed.

The cup 50 connected to the elevating mechanism (not shown) can be vertically moved with respect to the base 11 and the wafer W.

The nozzle arms 61 and 62 are disposed in the vicinity of the top surface of the wafer W; and fluids such as the processing solution, air and the like are discharged through openings of tip ends thereof. The fluid to be discharged may be selected in a predetermined manner from pure water,

liquid chemical or nitrogen gas. To the nozzle arms 61 and 62, there are connected moving mechanisms (not shown) for moving the nozzle arms 61 and 62 in a direction towards the center of the wafer W, respectively. In case where the fluids are discharged onto the wafer W, the nozzle arms 61 and 62 are moved to the positions above the wafer W. If the discharge is completed, the nozzle arms 61 and 62 are moved away outside the outer periphery of the wafer W. Further, the number of nozzle arms may be one or 3 or more, depending on the amount of the liquid chemical to be discharged or the kind thereof.

One end of the base 11 can be moved upward or downward by the substrate inclining mechanism 70 connected to the base 11, thereby tilting the base by an amount in the range of, e.g., 0 ~ 10 ° or 0 ~ 5 °, and the wafer chuck 20, the wafer W, the upper plate 30, the lower plate 40 and the cup 50, which are connected to the base 11, can be accordingly tilted by the same amount.

Fig. 3 is a partial cross sectional view showing a state where the wafer W and the like are tilted by the substrate inclining mechanism 70. It can be noted that the base 11 is tilted by the substrate inclining mechanism 70, and the wafer W and the like, which are directly or indirectly connected to the base 11, are tilted by an angle θ.

A solution supply unit 80 is to supply heated

processing solutions to the upper plate 30 and the lower plate 40, and contains a temperature controller 81, processing solution tanks 82, 83 and 84, pumps P1 ~ P5, valves V1 ~ V5 and a mixing box 85. Further, Fig. 1 shows a case of using two kinds of liquid chemicals, e.g., the liquid chemicals 1 and 2, but the numbers of processing tanks, pumps and valves may be set properly depending on the number of liquid chemicals mixed in the mixing box 85.

The temperature controller 81 having therein hot water and the processing solution tanks 82 ~ 84 is a device for heating the processing solutions (pure water and liquid chemicals 1 and 2) in the processing solution tanks 82 ~84 by using the hot water; and the processing solutions are appropriately heated, e.g., in the range from the room temperature to about 60 ℃. For example, a water bath, a heater installed inside the processing tanks 82 to 84 (e.g., an immersion heater) or a heater installed outside the processing tanks 82 to 84 (an external heater) may be employed for adjusting the temperature.

The processing solution tanks 82, 83 and 84 are to accommodate therein the pure water, and the liquid chemicals 1 and 2, respectively.

The processing solutions are drawn out from the processing solution tanks 82 ~ 84 by the pumps P1 ~ P3. Further, the processing solutions may be pushed out from the processing solution tanks 82 ~ 84 by pressurizing the

processing solution tanks 82 ~ 84, respectively.

The lines are opened or closed by the valves V1 ~ V3 to supply or to stop supplying the processing solutions. Further, valves V4 and V5 are to supply pure water of the room temperature (unheated) to the upper plate 30 and the lower plate 40, respectively.

The mixing box 85 is a vessel for mixing the liquid chemicals 1 and 2 from the processing solution tanks 83 and 84.

The liquid chemicals 1 and 2 are appropriately mixed at a predetermined ratio in the mixing box 85 and the temperatures thereof are adjusted therein to thereby be transferred to the upper plate 30. Further, the pure water can be sent to the lower plate 40 at a controlled temperature.

(Details of the electroless plating processings)

Fig. 4 is a flowchart for showing an exemplary sequence of performing the electroless plating on the wafer W by using the electroless plating apparatus 10. Figs. 5 through 11 present partial cross sectional views for showing respective statuses of the electroless plating apparatus in case of performing the electroless plating by following the sequence described in Fig. 4. Hereinafter, the sequence will be discussed in detail by using Figs. 4 ~ 11.

(1) Maintaining of the wafer W (step S1 and Fig. 5)

The wafer W is maintained on the wafer chuck 20. For example, the wafer W is mounted on the wafer chuck 20 by a drawing arm (substrate transfer mechanism) (not shown), on which the wafer W is drawn. Further, the wafer W is maintained by the wafer supporting claw 21 of the wafer chuck 20. Still further, the cup 50 can be lowered down to move the drawing arm in the horizontal direction below the top surface of the wafer W.

(2) Pre-treatment of the wafer W (step S2 and Fig. 6)

Pre-treatment of the wafer W is performed by rotating the wafer W and supplying the processing solution from the nozzle arm 61 or 62 onto the wafer W.

The wafer W is rotated by rotating the wafer chuck 20 with the hollow motor 12, and the rotation speed may be in the range of, e.g., 100 ~ 200 rpm.

Any one or both of the nozzle arms 61 and 62 are moved above the wafer W to discharge the processing solutions. As for the processing solutions supplied from the nozzle arms 61 and 62, there are sequentially supplied, e.g., pure water for cleaning the wafer W and a liquid chemical solution for the catalytically active processing of the wafer W, depending on the object of the pre-treatment. At this time,

the amount of discharge may be, e.g., about 100 mL, enough to form a puddle (layer) of the processing solution on the wafer W. However, the amount of discharge may be increased, if necessary. Further, the processing solution to be discharged may be appropriately heated (e.g., in the range from room temperature to about 60 ℃).

(3) Heating of the wafer W (step S3 and Fig. 7)

The wafer W is heated to be kept at an optimum temperature for the reaction of the plating solution.

The lower plate 40 is heated and disposed close to the bottom surface of the wafer W (e.g., a gap between the bottom surface of the wafer W and the upper surface of the lower plate 40: about 0.1 ~ 2 mm); and the pure water heated by the liquid supply unit 80 is supplied through the processing solution injection opening 41. Heated pure water fills the gap between the bottom surface of the wafer W and the upper surface of the lower plate 40 to heat the wafer W.

Further, the water W is heated while it being rotated, so that uniformity in a wafer heating is improved.

By heating the wafer W by using liquid such as pure water or the like, it becomes easy to rotate the wafer W while maintaining the lower plate 40 not to be rotated. Moreover, the bottom surface of the wafer W can be prevented from being contaminated.

The wafer W may be heated by using different heating means. For example, the wafer W may be heated by radiant heat from a heater or lamp. Further, the wafer W may be heated by making a contact with heated lower plate 40.

(4) Supplying of the plating solution (step S4 and Fig. 8)

The upper plate 30 is heated and disposed close to the top surface of the wafer W (e.g., a gap between the top surface of the wafer W and the lower surface of the upper plate 30: about 0.1 ~ 2 mm) to supply the liquid chemical for plating (plating solution) through the processing solution injection openings 31 (e.g., 30 ~ 100 mL/min). Supplied plating solution fills the gap between the top surface of the wafer W and the lower surface of the upper plate 30, and then, is drained out to the cup 50. At this time, the temperature of the plating solution is adjusted by the upper plate 30 (e.g., in the range from room temperature to about 60 ℃). Further, it is preferable that the temperature of the plating solution to be supplied is adjusted by the liquid supply unit 80.

Here, since the wafer W is rotated by the wafer chuck 20, uniformity in the coating to be formed on the wafer W can be improved. For example, the wafer W is rotated at 10 ~ 50 rpm.

Further, the upper plate 30 may be pre-heated at any step of S1 ~ S3. By performing the heating of the upper plate 30 in parallel with other processings, the processing time of the wafer W can be reduced.

As described above, the coating is formed on the wafer W by supplying onto the wafer W the plating solution heated at a desired temperature. By rotating the wafer W while the plating solution being supplied thereonto, it is possible to improve uniformity in the coating formation on the wafer W.

In case when the above-described plating solution being supplied, it may be possible to perform following processings:

1) The wafer chuck 20 and the upper plate 30 may be tilted by the substrate inclining mechanism 70, prior to the supply of the plating solution.

The wafer W is tilted, so that a gas staying in a space between the wafer W and the upper plate 30 is immediately removed, and the space will be refilled with the plating solution. If the gas staying in the space between the wafer W and the upper plate 30 is incompletely removed, bubbles will be formed to remain in the space between the wafer W and the upper plate 30, to thereby deteriorate uniformity in the coating to be formed.

Further, the coating formation by using the plating solution is accompanied with the generation of a gas (e.g.,

hydrogen), and bubbles are produced due to the resultant gas. Thus, uniformity in the coating may be deteriorated.

The inclination of the wafer W by the substrate inclining mechanism 70 will reduce the production of the bubbles and facilitate escape of the resultant bubbles, so that the uniformity in the coating can be improved.

2) The temperature of the plating solution may be varied as a function of time.

In this manner, there may change in a structure or a composition of the coating in the direction along the depth thereof.

3) The plating solution may be supplied intermittently, not continuously, during the formation of the coating. By efficiently utilizing the plating solution supplied onto the wafer W, it is possible to reduce the amount of the plating solution used.

(5) Cleaning of the wafer W (step S5 and Fig. 9)

The wafer W is cleaned by using the pure water. The cleaning may be performed by using the pure water as the processing solution to be discharged through the processing solution injection opening 31 of the upper plate 30, instead of using the plating solution. At this time, the pure water

can be supplied from the processing solution injection opening 41 of the lower plate 40.

In case when cleaning the wafer W, the nozzle arms 61 and 62 may be used. At this time, the plating solution is stopped to be supplied from the processing solution injection opening 31 of the upper plate 30, and then the upper plate 30 is separated from the wafer W. After that, the nozzles 61 and 62 are moved above the wafer W to supply the pure water. In the same manner, it is preferable that the pure water is supplied from the processing solution injection opening 41 of the lower plate 40.

Since the wafer W is cleaned while being rotated, uniformity in the wafer cleaning can be improved.

(6) Drying of the wafer W (step S6 and Fig. 10)

After the pure water is supplied onto the wafer W, the wafer W is rotated at a high speed to get rid of the pure water thereon. Drying of the wafer W may be facilitated by using the nitrogen gas ejected from the nozzle arms 61 and 62, if necessary.

(7) Removing of the wafer W (step S7 and Fig. 11)

If the wafer W is dried, the wafer W is not maintained by the wafer chuck 20 any more. After that, the wafer W is

removed from the wafer chuck 20 by the drawing arm (substrate transfer mechanism) (not shown).

(Characteristics of the electroless plating apparatus 10)

The electroless plating apparatus 10 has characteristics as follows:

(1) The plating solution is supplied from the upper plate 30 to fill the gap between the wafer W and the upper plate 30, and discharged from the outer periphery of the wafer W, while the wafer W and the upper plate 30 are disposed close to face each other. In this way, the flow of the plating solution is formed on the wafer W in a direction towards the outer periphery from the center thereof, to thereby supply fresh plating solution onto the wafer W.

(2) The wafer W and the upper plate 30 are disposed close to each other, so that the plating solution is efficiently used, and thus the amount of plating solution to be used can be reduced.

(3) The wafer W is rotated during the coating formation, so that in-surface uniformities in a supply of the plating solution onto the wafer W, and further, in a

film thickness of the coating can be obtained.

(4) The top and the bottom surface of the wafer W can be uniformly heated by using the upper plate 30 and the lower plate 40. As a result, uniformity in a characteristic of the coating to be formed on the wafer W can be obtained.

(5) The area for installing the apparatus needs not to be larger since it is sufficient to have a size corresponding to that of the wafer W.

(Other embodiments)

The embodiment of the present invention is not limited to the aforementioned embodiments, and various changes and modifications may be made. Namely, changed and modified embodiments may be contained in the technical fields of the present invention.

(1) For example, there may be used as a substrate a glass substrate or the like other than the wafer W.

(2) Supplying the processing solution (including the plating solution) onto the substrate is not necessarily performed continuously, and may be performed somewhat intermittently. Since the fresh processing solution is

supplied onto the substrate at least while the processing solution is supplied onto the substrate, uniformity in a processing of the substrate can be maintained. Further, even though the supply of the processing solution is temporarily stopped, uniformity in the processing of the substrate is not significantly deteriorated as long as the change in the processing solution during the stop time period is not so large.

(3) The heater disposed at the upper plate 30 may be divided into plural ones. By dividing the heater into plural, temperatures in plural regions of the upper plate 30 can be controlled individually, so that uniformities in a temperature distribution of the upper plate 30, and further in the processing of the substrate can be improved.

[Industrial Applicability]

In an electroless plating apparatus and an electroless plating method in accordance with the present invention, it is possible to form a coating on a substrate with high uniformity even in case of using a small amount of processing solution. Therefore, the coating can be used and manufactured in the industrial fields.